



A Citizen's Guide to Using Indigenous And Exogenous Microorganisms In Bioremediation

Technology Innovation Office

Technology Fact Sheet

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What Is Bioremediation?

Bioremediation uses naturally occurring microorganisms (yeast, fungi and/or bacteria) to degrade — break down — hazardous substances into less toxic or nontoxic substances. Microorganisms, just like humans, eat and digest organic substances for nutrients and energy. Certain microorganisms can digest organic substances that are hazardous to humans. The organic contaminants degrade into harmless products consisting mainly of carbon dioxide and water. Some examples of organic contaminants include fuels, such as oil spills, and solvents.

Microorganisms must thrive in order for bioremediation to take place. In addition to the food source provided by the organic contaminants, some microorganisms require additional nutrients. To help the microorganisms survive, several bioremediation technologies have been developed. The specific bioremediation technology used is determined by the type of microorganisms present, as well as the site

conditions. The types of microorganisms present are an important consideration because different microorganisms degrade different types of compounds and survive under different conditions.

What Are Indigenous And Exogenous Microorganisms?

Indigenous microorganisms are those microorganisms which are native to the site. To stimulate the growth of these indigenous microorganisms, the soil conditions, such as temperature, pH, and oxygen and nutrient content, may need to be adjusted.

If the microorganisms needed to degrade the contaminant are not present in the soil, microorganisms from other locations, whose effectiveness has been tested in laboratories, are added to the contaminated soil. These are called **exogenous** microorganisms. The soil conditions sometimes need to be adjusted to ensure that the exogenous microorganisms will thrive.

Indigenous and Exogenous Microorganisms Profile

- **Indigenous microorganisms** are already present at the site to degrade the organic contaminants into nonhazardous substances.
- **Exogenous microorganisms** are not native to the site. These microorganisms can be cultured, in a lab or on site, to degrade contaminants.

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What Other Industries Use Microorganisms?

In addition to degrading hazardous substances, microorganisms have a long history of use by a variety of industries. For example, the medical industry uses a fungus to produce the antibiotic penicillin, which is used to destroy harmful bacteria. The beer industry uses yeast during the fermentation process to make alcoholic beverages.

How Are Indigenous Microorganisms Used?

Figure 1, below, illustrates the use of both indigenous and exogenous microorganisms. In most sites undergoing bioremediation, indigenous microorganisms are used. The process begins by **sampling** the contaminated soil. These samples are taken to a laboratory and **studied**. In the laboratory, the types of microorganisms present in the contaminated soil and their optimal living conditions are determined. If the indigenous microorganisms are able to successfully degrade the contaminant, exogenous microorganisms are not needed.

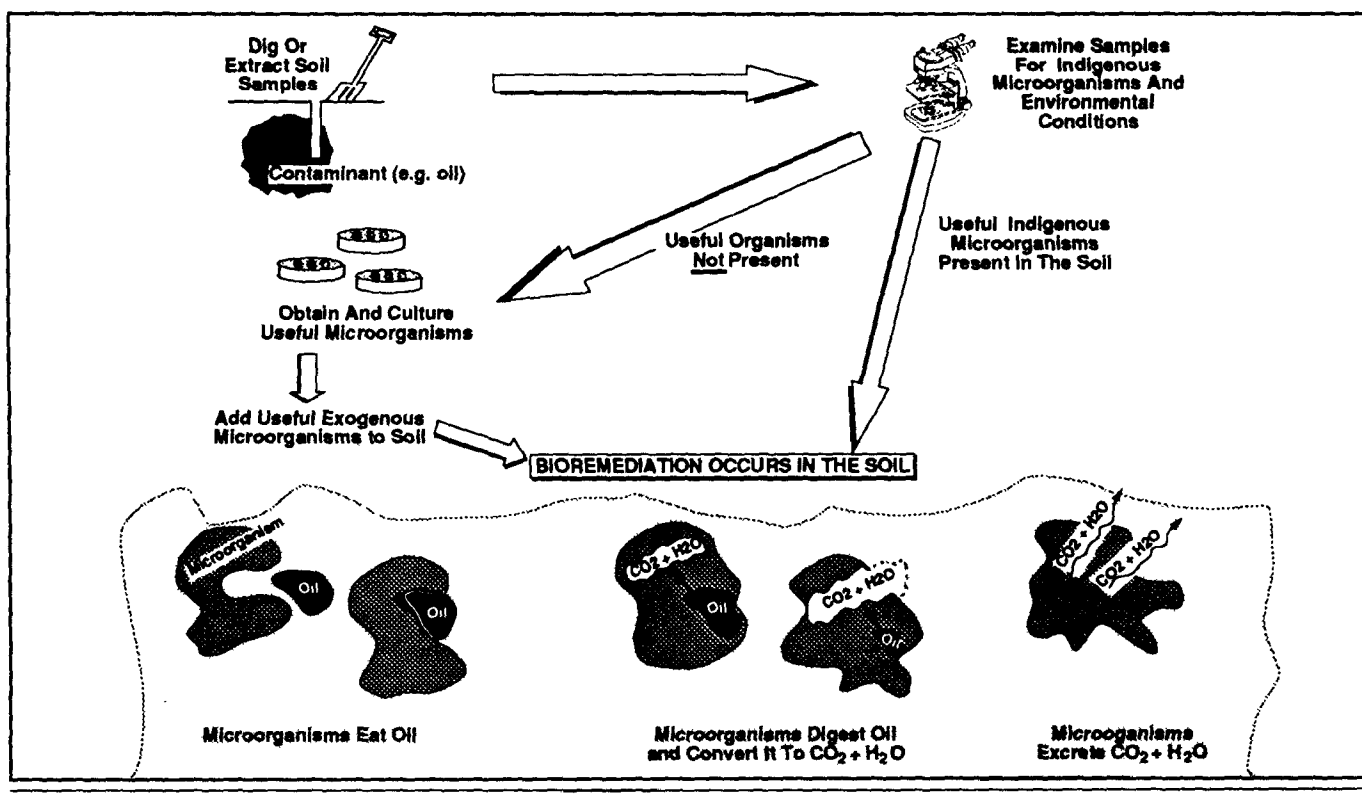
If the soil conditions are right, the indigenous microorganisms will use the contaminants in the soil as a food source and convert them to nonhazardous substances. The main end products of this conversion reaction are carbon dioxide and water ($\text{CO}_2 + \text{H}_2\text{O}$). In order to see if the bioremediation reaction is indeed occurring, the level of end products ($\text{CO}_2 + \text{H}_2\text{O}$) is monitored for an increase in levels and the contaminants are checked for a decrease in levels. If the reaction is not occurring, the soil conditions may need adjusting.

Once the degradation of the contaminants is completed, most of the indigenous microorganisms will die because they have used all of their food source. The dead microorganisms pose no contamination risk because they have already degraded the contaminants into nontoxic substances.

How Are Exogenous Microorganisms Used?

As with indigenous bioremediation, the first step in this process is soil sampling. The samples are taken to a laboratory and studied. Here, the types of microorganisms are identified. If microorganisms capable of degrading the contaminants are not present, then exogenous microorganisms may be considered for introduction into the soil.

Figure 1
Use of Indigenous and Exogenous Microorganisms



However, the toxicity of the soil needs to be determined to ensure that the exogenous organisms will survive. Although they are not naturally present at the contaminated site, these exogenous microorganisms are naturally occurring at other locations.

The exogenous microorganisms are taken from other locations and 'cultured' in the laboratory. This means the microorganisms are placed in optimal living conditions (for example, perfect temperatures and an abundant source of nutrients) so that they can multiply. When they have multiplied to great numbers, these microorganisms can be taken to the site and added to the contaminated soil.

If the soil conditions are right, the indigenous microorganisms will use the contaminants in the soil as a food source and convert them to nonhazardous substances. The main end products of this conversion reaction are carbon dioxide and water ($\text{CO}_2 + \text{H}_2\text{O}$). In order to see if the bioremediation reaction is indeed occurring, the level of end products ($\text{CO}_2 + \text{H}_2\text{O}$) is monitored for an increase in levels and the contaminants are checked for a decrease in levels. If the reaction is not occurring, the soil conditions may need adjusting.

Once the degradation of the contaminants is completed, most of the exogenous microorganisms will die because they have used all of their food source. The dead microorganisms pose no contamination risk because they have already degraded the contaminants into nontoxic substances. Exogenous microorganisms will not permanently affect the soil's composition.

What Is An Innovative Treatment Technology?

Treatment technologies are processes applied to the treatment of hazardous waste or contaminated materials to permanently alter their condition through chemical, biological, or physical means. Technologies that have been tested, selected or used for treatment of hazardous waste or contaminated materials but lack well-documented cost and performance data under a variety of operating conditions are called innovative treatment technologies.

Are Genetically Engineered Microorganisms Being Used?

The genetic engineering of microorganisms for bioremediation is still in the research and development stages and has not yet been used commercially in the United States. As the knowledge and uses of genetic engineering increase, it may be an important way to enhance bioremediation technology. Uses of genetically engineered microorganisms for bioremediation are regulated by the Toxic Substances Control Act.

Which Sites Are Appropriate For Indigenous And/OR Exogenous Microorganisms?

Indigenous bioremediation, exogenous bioremediation, or a combination of the two can be useful depending upon site conditions. Relying on indigenous microorganisms is appropriate if useful strains are present and concentrated in the area of contamination. If indigenous organisms are already surviving in the original soil conditions, the process of optimizing the soil's conditions for these microorganisms is not as complicated as it is for exogenous microorganisms. Using indigenous microorganisms also tends to be less expensive than culturing and introducing exogenous microorganisms into the soil. For all of these reasons, most bioremediation technologies make use of indigenous microorganisms whenever possible. However, exogenous microorganisms are needed when useful microorganisms are not already present.

A thorough scientific assessment of the contaminated soil and the soil conditions must be performed to determine whether indigenous or exogenous microorganisms would make the bioremediation more effective.

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For More Information

EPA prepared this fact sheet to provide basic information on indigenous and exogenous microorganisms. Additional technical reports are listed below. The document with a "PB" designation is available by contacting the National Technical Information Service (NTIS) at 1-800-336-4700. Mail orders can be sent to:

**National Technical Information Service
Springfield, VA 22161**

Other documents may be obtained by contacting:

**Center for Environmental Research Information
26 West Martin Luther King Drive
Cincinnati, OH 45268
(513) 569-7562**

There may be a charge for these documents.

- **Bioremediation of Contaminated Surface Soil, PB90-164047.**
- **Engineering Bulletin-Slurry Biodegradation, EPA/540/2-90/016.**
- **Understanding Bioremediation: A Guide Book for Citizens, EPA 540/2-91/002.**

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